Experiments conducted under NOAA's Climate Test Bed

Subseasonal forecasting with the NCEP-CFS: Impact of initial conditions and model resolution

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and

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The Operational Climate Forecast System

Atmosphere

- **Global Forecast System 2003 (GFS03)**
- **T62 in horizontal; 64 layers in vertical**
- **Recent upgrades in model physics**
  - **Solar radiation (Hou, 1996)**
  - **cumulus convection (Hong and Pan, 1998)**
  - **gravity wave drag (Kim and Arakawa, 1995)**
  - **cloud water/ice (Zhao and Carr,1997)**

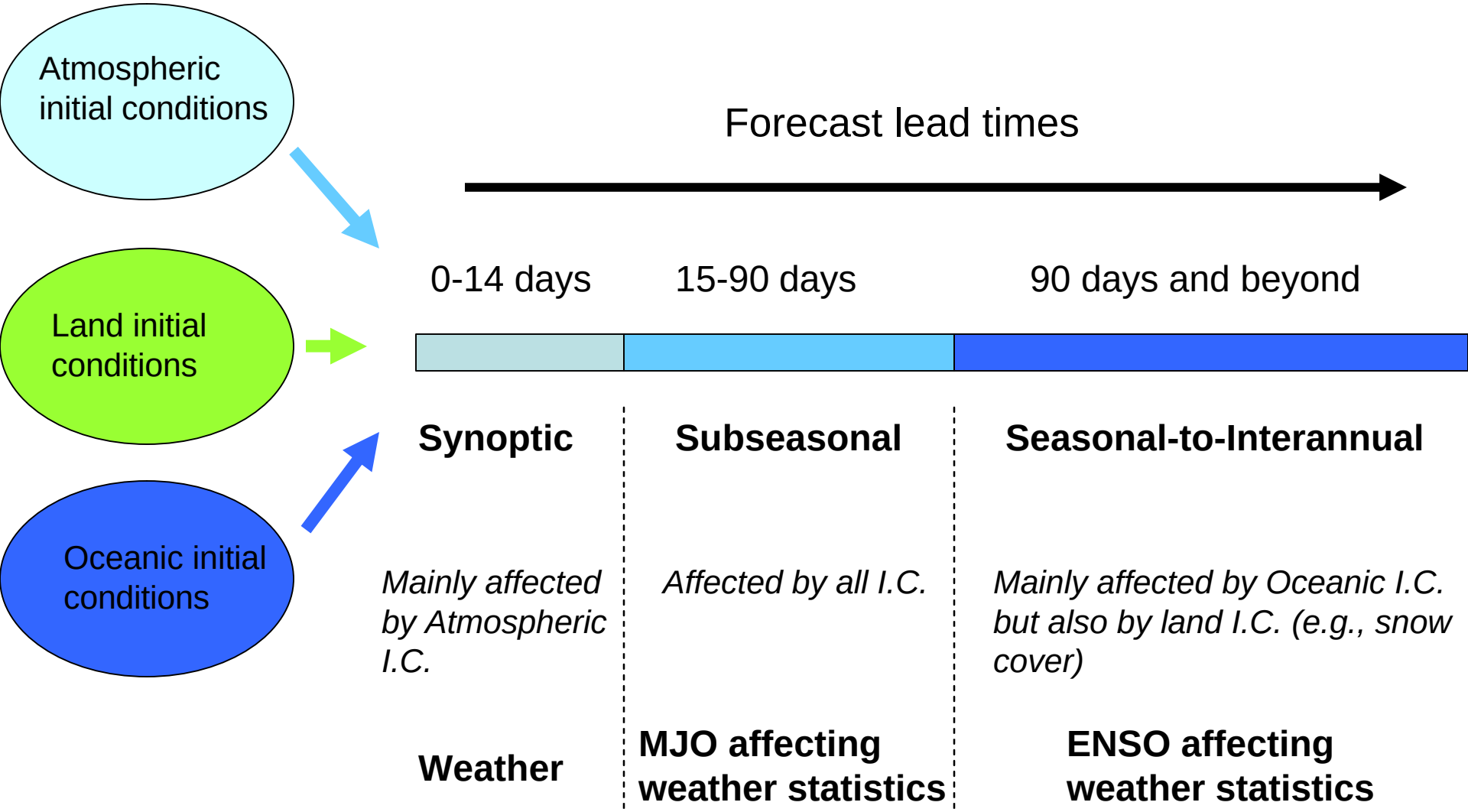
Coupling

once per day, no flux correction.

Ocean

- **GFDL MOM3 (Pacanowski and Griffies, 1998)**
- **1/3°´1° in tropics; 1°´1° in extratropics; 40 layers**
- **Quasi-global domain (74°S to 64°N)**
- **Free surface**

Dynamical Forecasting: from Weather to Climate

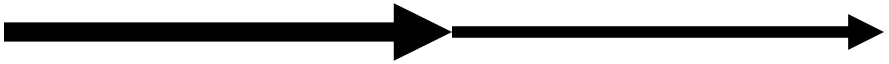


Issues : Which Model Resolution?

Currently:

Weather forecast (GFS) initialized by GDAS

T382L64 to 7 days T190L64 to 16 days

GDAS 

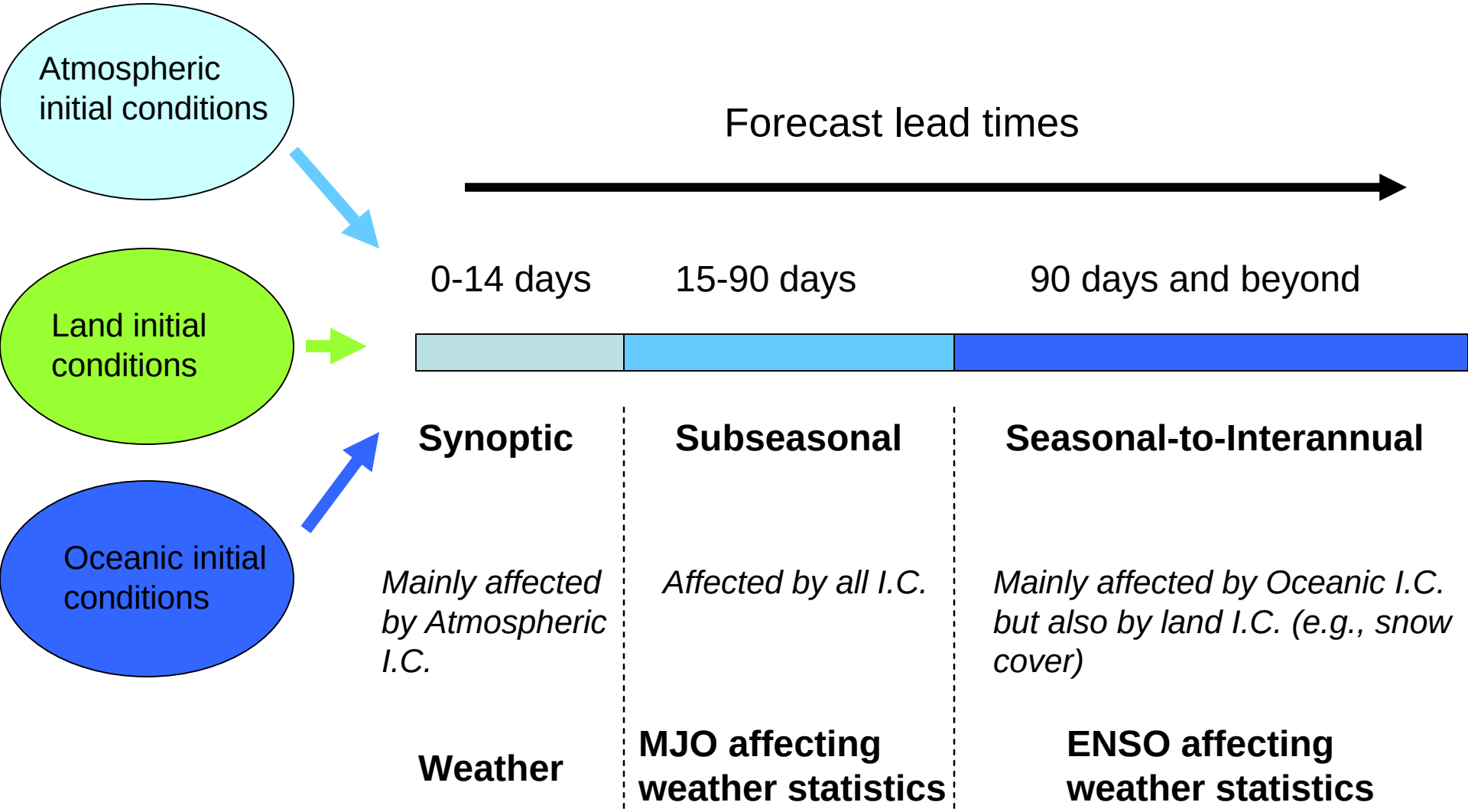
Seasonal forecast (CFS) initialized by CDAS-2/GODAS

T62L64 to 9 months

CDAS 

(Next implementation T126L64)

Dynamical Forecasting: from Weather to Climate

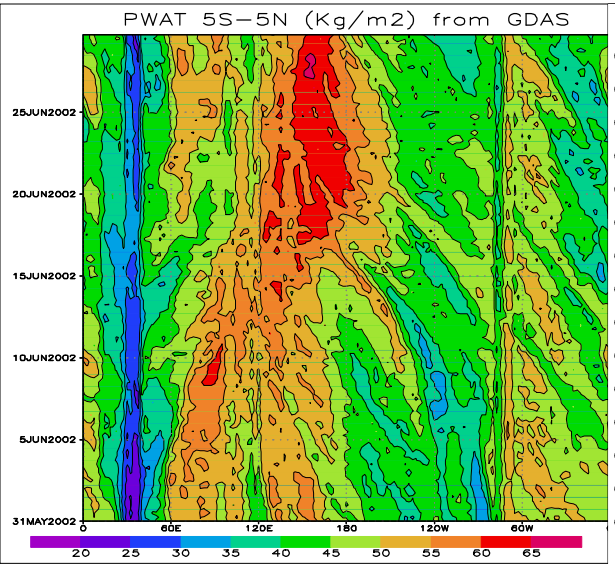


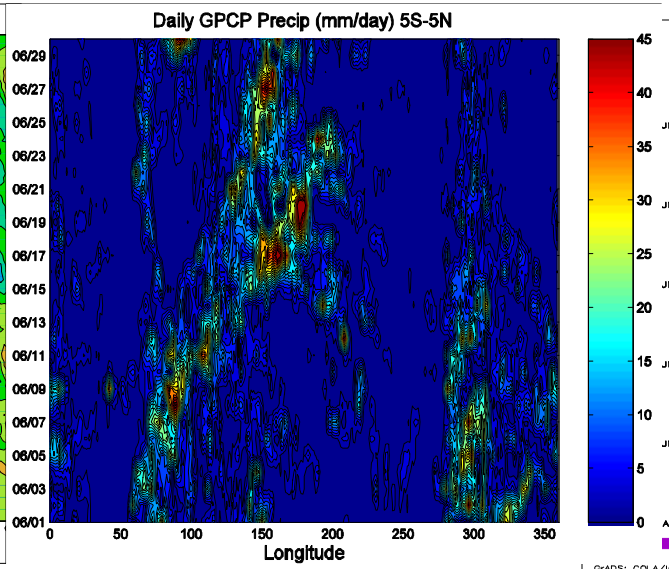
Issues : Initialization

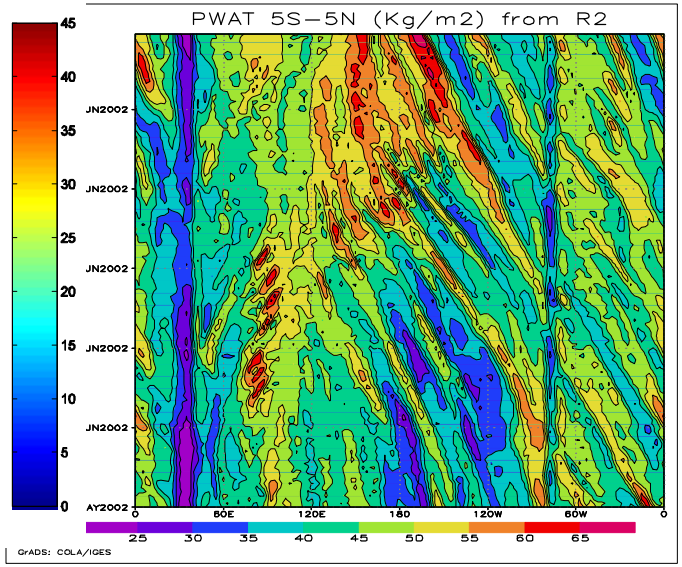
- Is it better to use a frozen reanalysis system (which is preferable when bias correction is crucial) rather than the best initial conditions available at the time and an estimate for bias correction?

- What is the impact of initializing the subseasonal forecast by GDAS (operational analysis) or Reanalysis-2?

GDAS *vs. GPCP vs.* Reanalysis-2 for June 2002



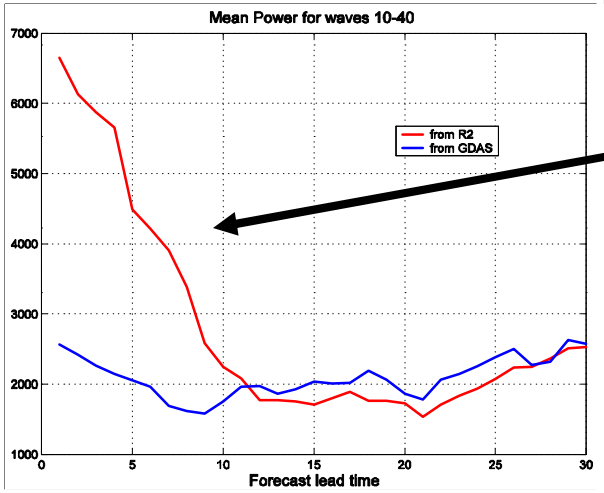




GDAS Precipitable Water

GPCP Precipitation

Reanalysis 2 Precipitable Water



drift

Time evolution of mean energy at wave numbers 10-40 when CFS is initialized by R2 (red) or by GDAS (blue).

Retrospective forecast design:

May 23rd to August 11th from 2002 to 2006

1 forecast every 5 days, with additional re-forecasts at the beginning of each month

Forecast lead: 60 days

Model resolution:

***Atmosphere*: T62 = 200Km x 200Km**

T126 = 100Km x 100Km

T254 = 50Km x 50Km

***Ocean*: the standard CFS resolution**

Initial conditions:

***Atmosphere, Land*: from Reanalysis 2 and from GDAS**

***Ocean*: from GODAS**

Is there an impact of resolution to large scales?

Consider:

- Root mean square error of zonal wind at 200 hPa (U200) averaged between 20ºS and 20ºN.
- Computation using 105 hindcasts for 144 longitudinal points
- Anomalies are defined in reference to a mean state computed using the five years (2002-2006)
- Validating against Reanalysis-2

U200 averaged between 20S-20N: no climatologies subtracted

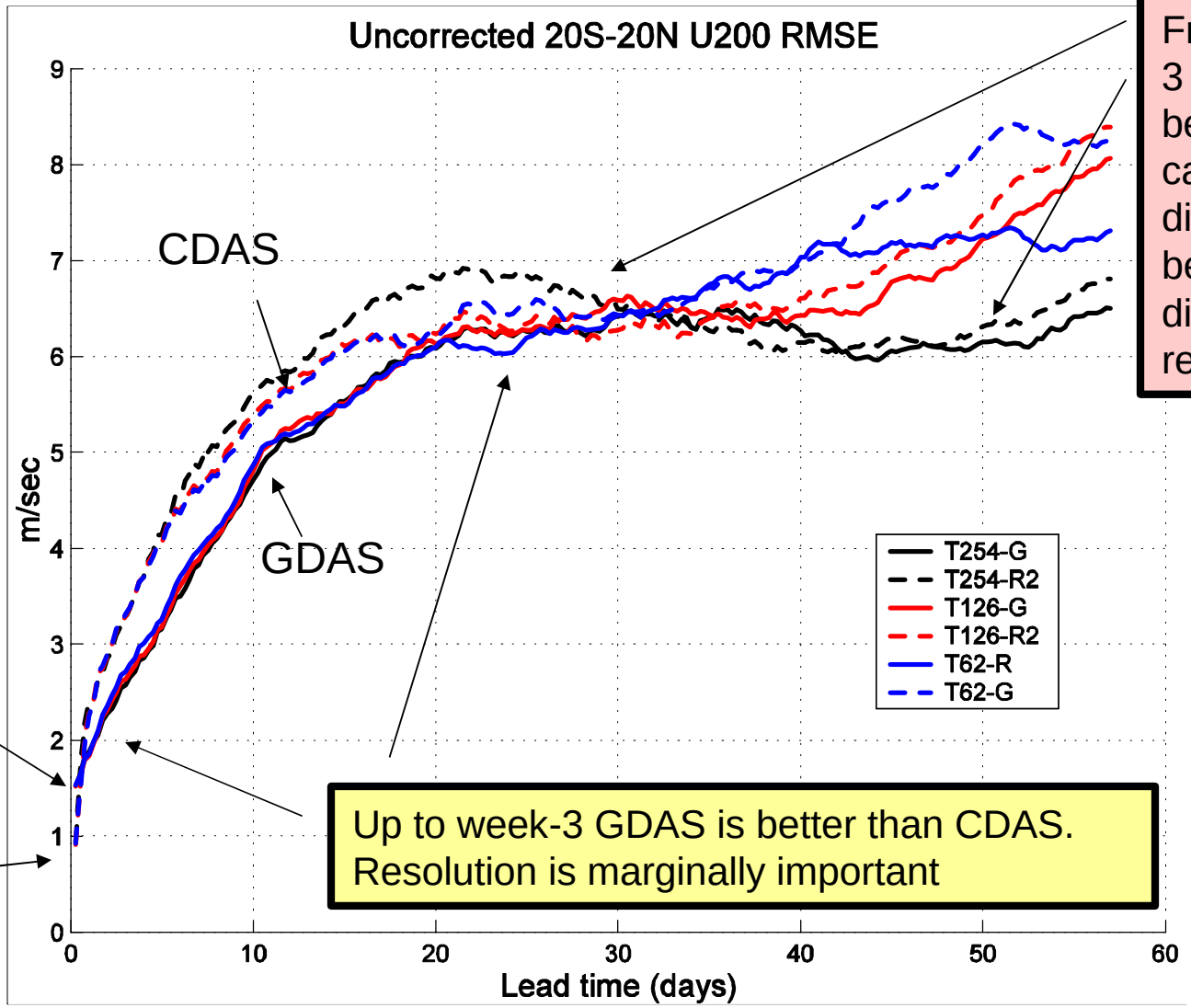
Black = T254

Red = T126

Blue = T62

CDAS

GDAS

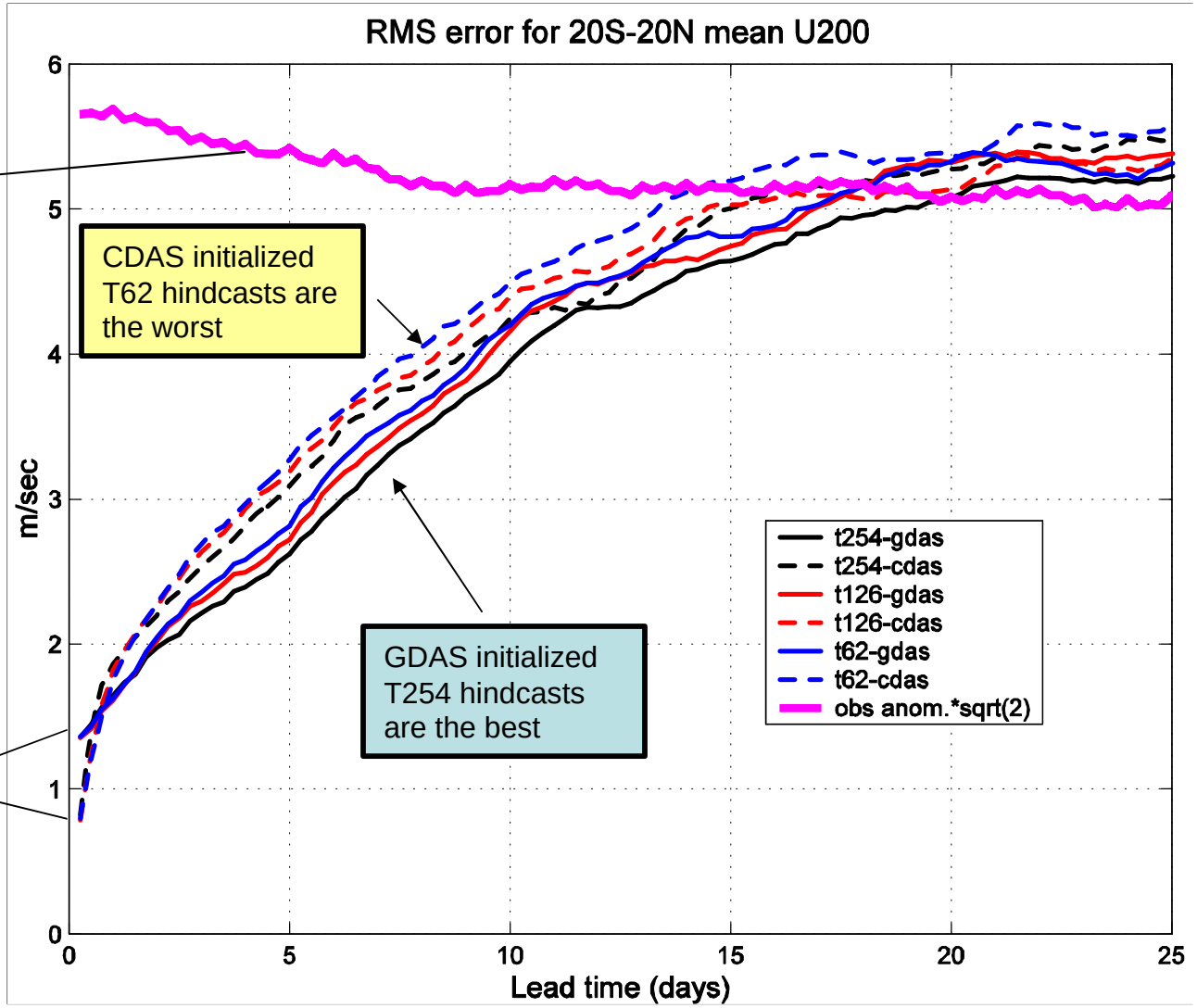


From week 3 and beyond we can clearly distinguish between different resolutions

Because we validate against CDAS (starting from 06Z)

Up to week-3 GDAS is better than CDAS. Resolution is marginally important

U200 averaged between 20S-20N: climatologies subtracted

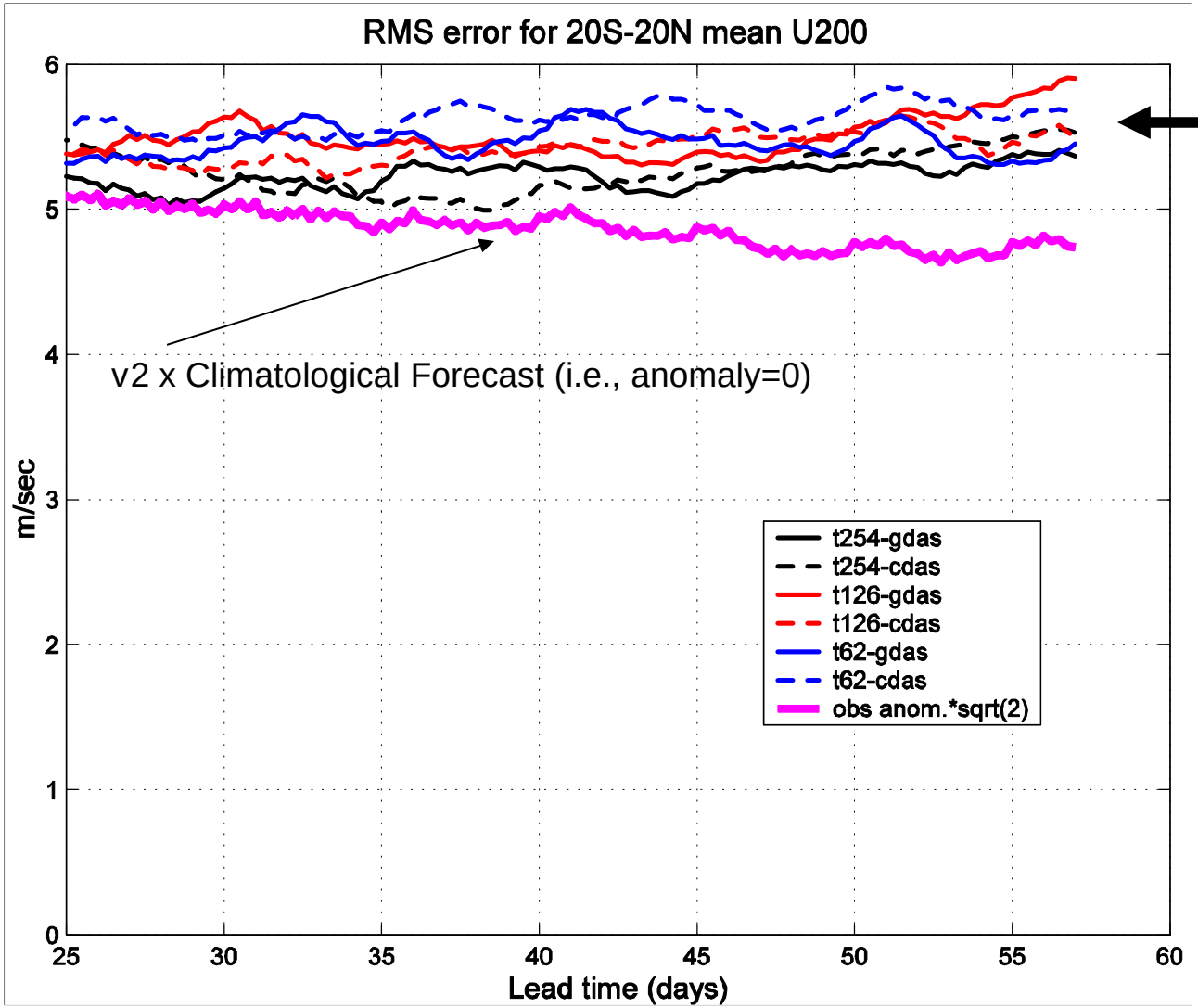


v2 x Climatological Forecast

Because we validate against CDAS (starting from 06Z)

Lead times from 0 to 25 days

U200 averaged between 20S-20N climatologies subtracted



We still can distinguish the hindcasts as a function of resolution.

Lead times from 25 to 57 days

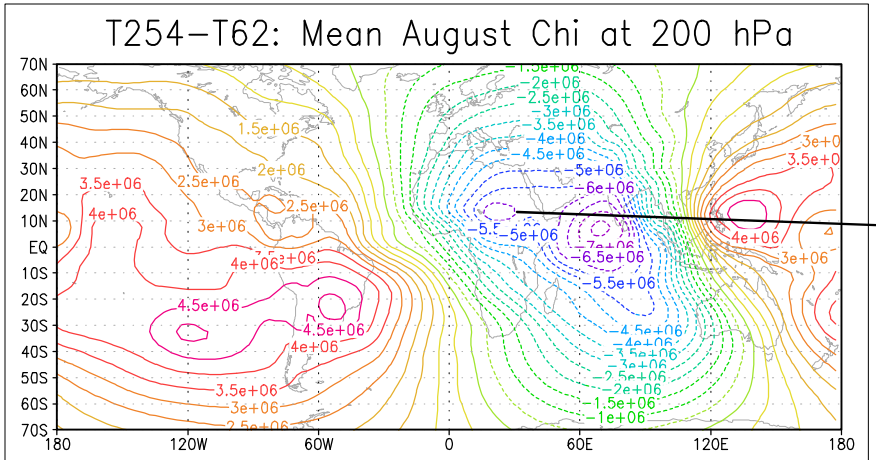
A first conclusion:

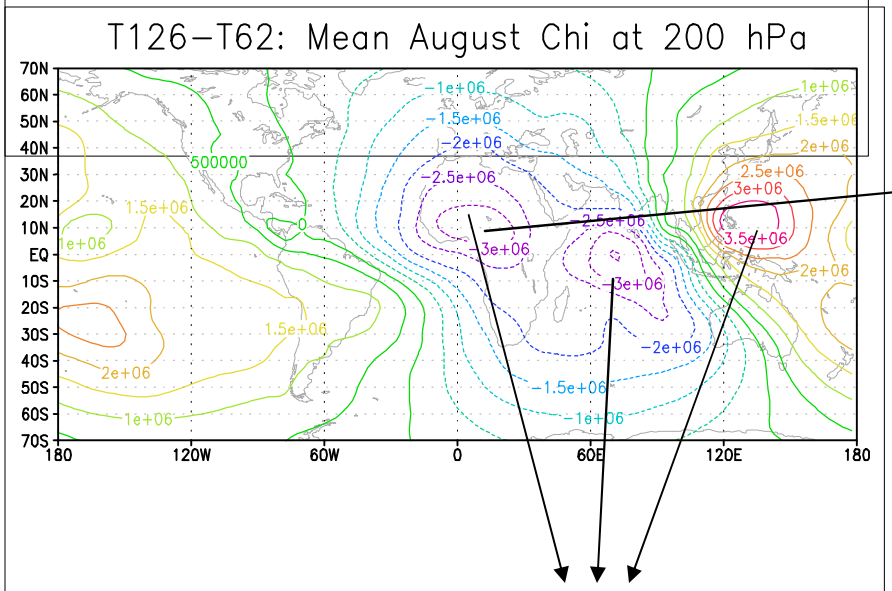
- There is impact of both resolution and initial conditions to large scales features at lead times beyond week 2.
- Of course, this impact could be more important for more local scales.

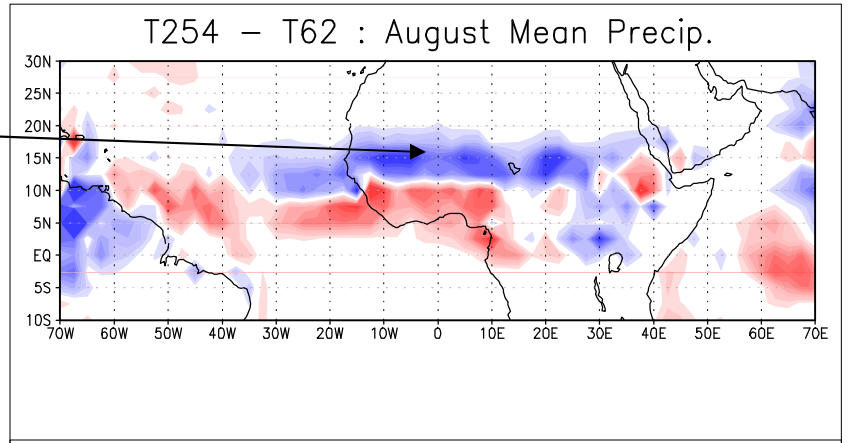
Impact to more local features

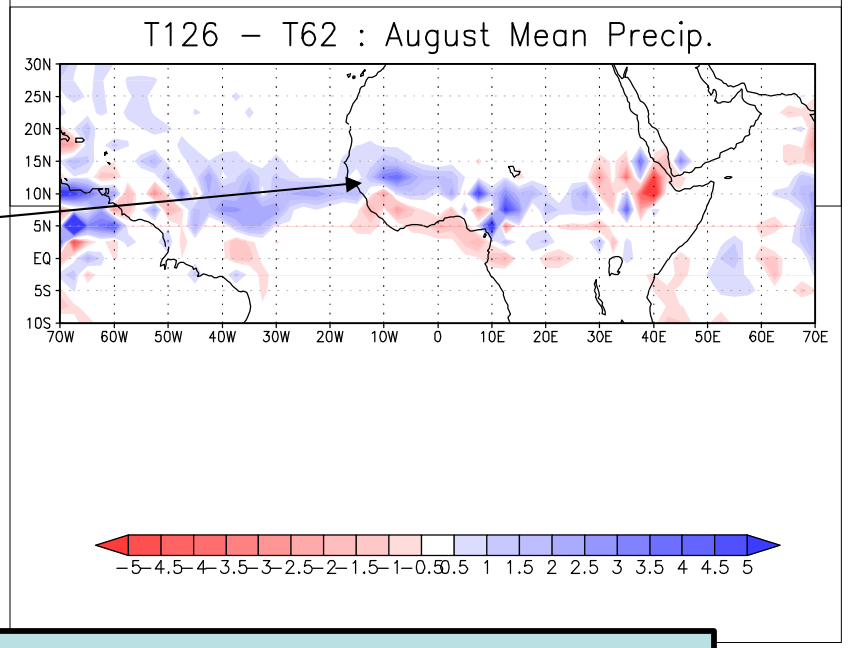
- We now explore the impact of resolution to mean August (2002-2006) features forecasted from initial conditions (CDAS and GDAS) on July 2nd, 3rd, 5th, 6th, 7th, 10th and 12th i.e., a total of 70 hindcasts

- Velocity potential at 200 hPa at a global scale and precipitation over Tropical Africa and Atlantic.



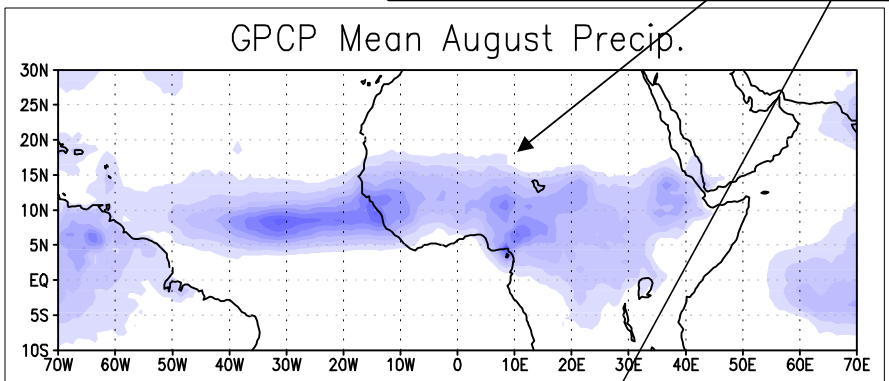


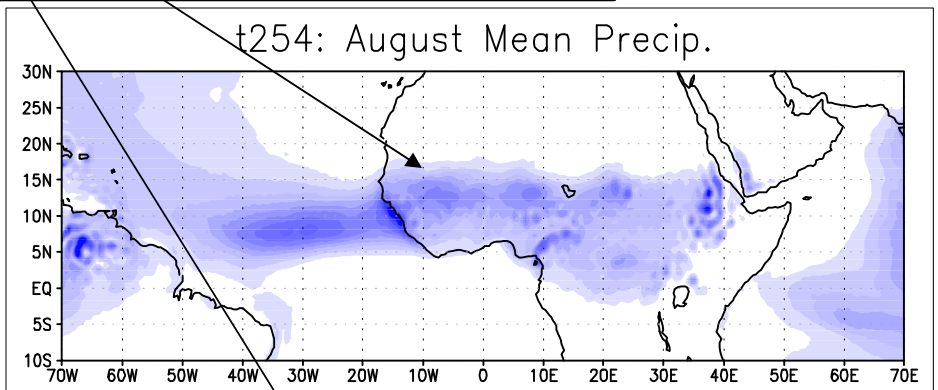


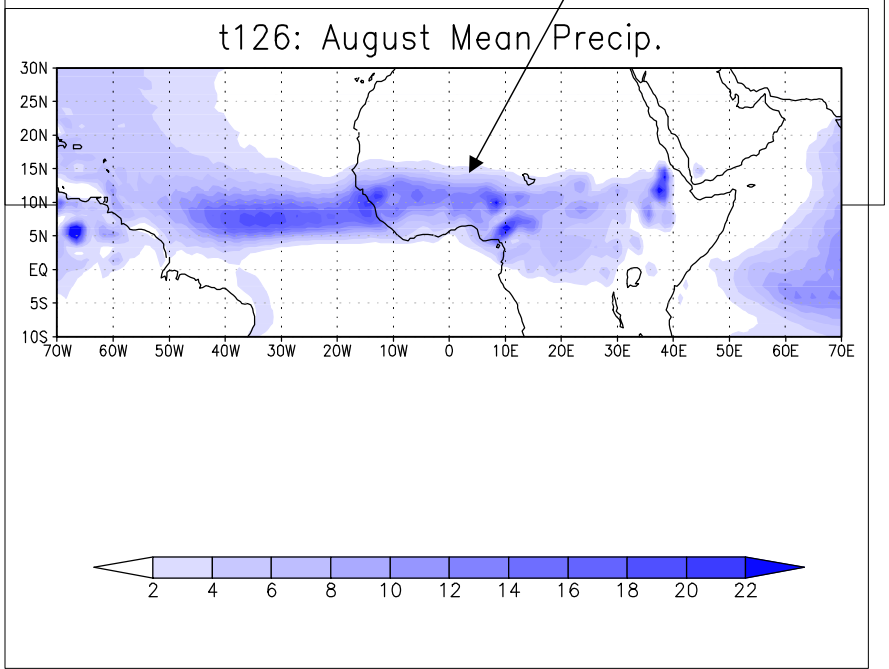


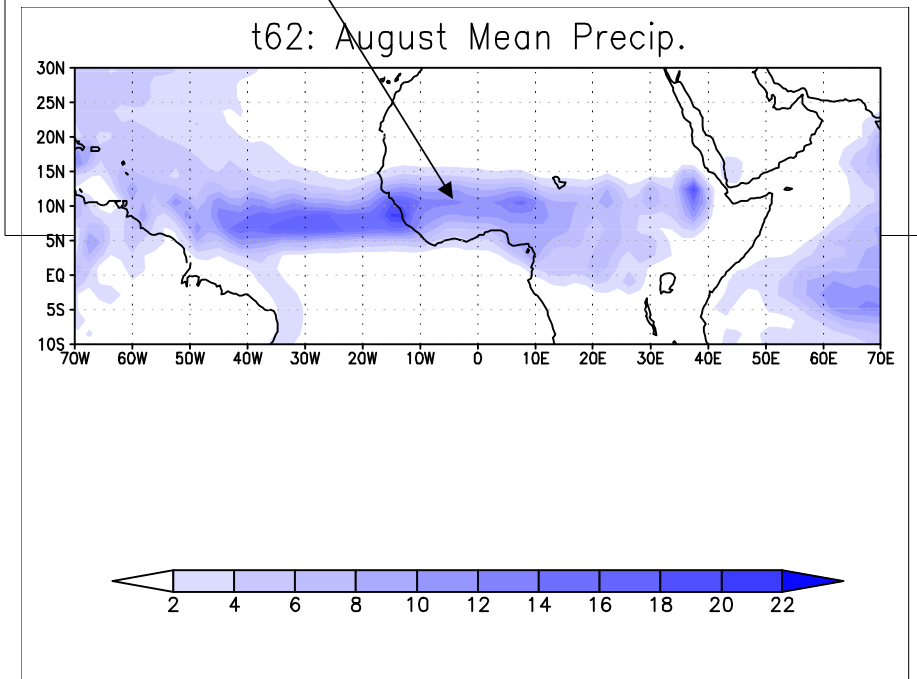
As resolution increases there is a shift of upper level divergence from the Philippines Sea to the Arabian Sea and over the Sahel which goes along with a northward shift of precipitation there.

In fact, the northward shift of the mean precipitation with resolution improves its simulation

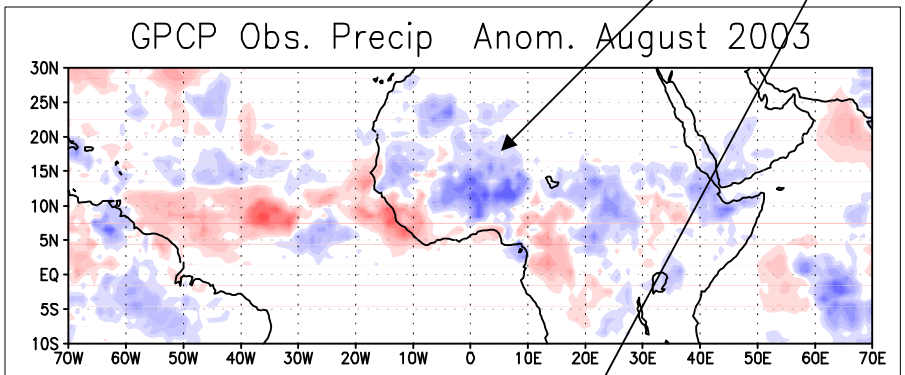


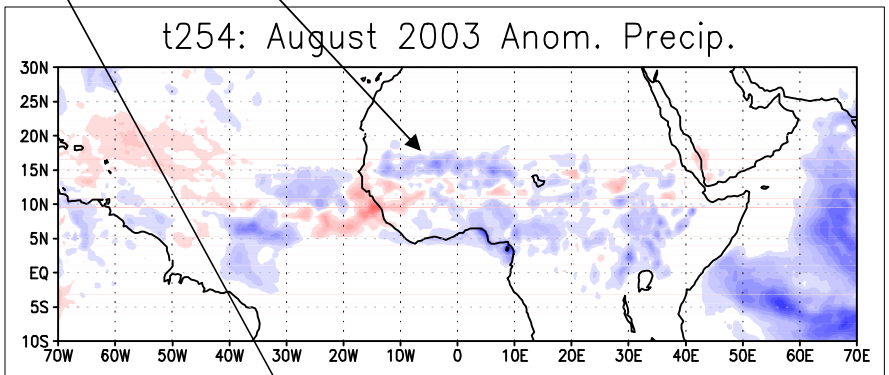


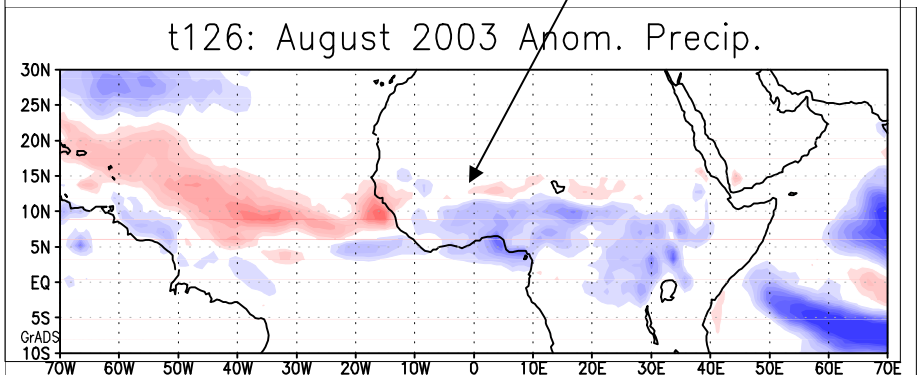


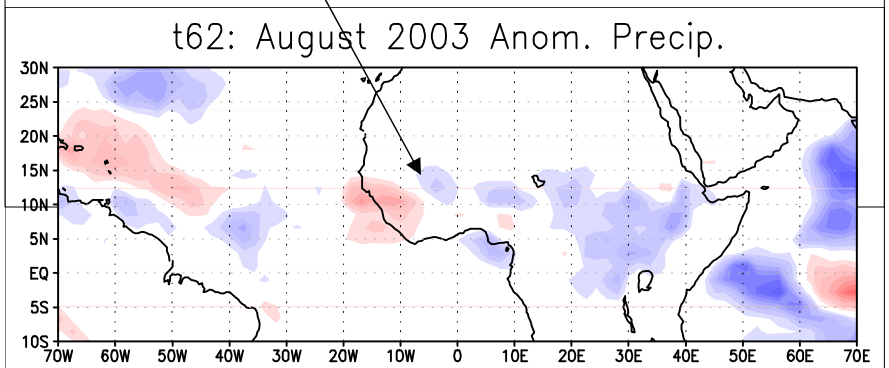


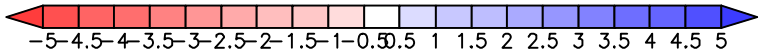
There are also good indications that the forecast skill increases with resolution. As an example we show here August 2003 (a wet year) as forecasted by initial conditions in the first half of July (14-member ensemble)

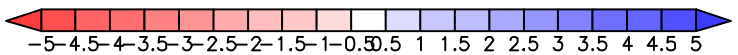












For more details on subseasonal forecasting over the Sahel please visit our poster at the AMMA session on Thursday…

Other areas:

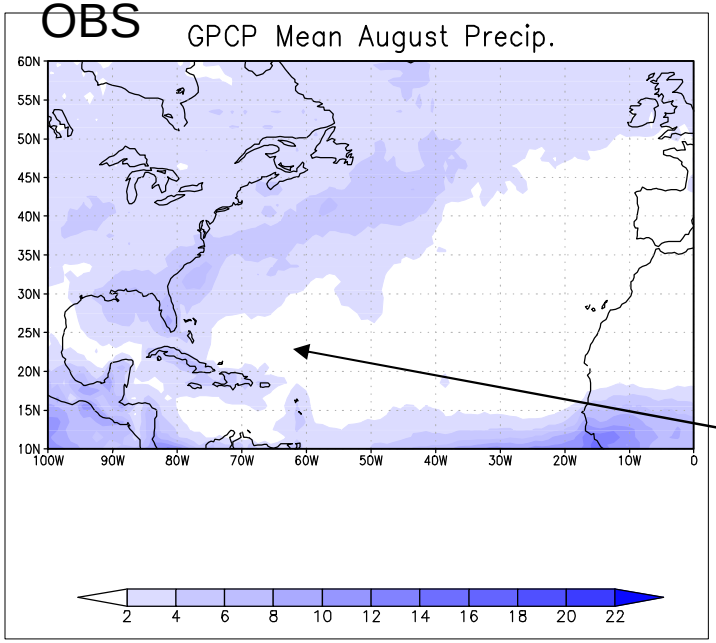
North American Continent

Tropical Atlantic

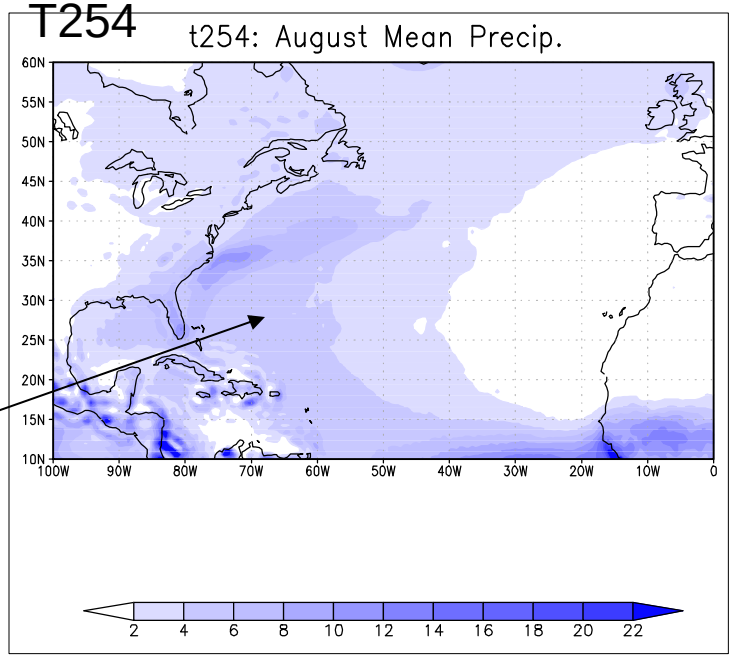
Mean August Precipitation

The mean August precipitation is computed by averaging hindcasts with initial conditions from July 2nd, 3rd, 5th, 6th, 7th, 10th and 12th using both CDAS and GDAS over the 5 years of hindcasts (i.e., based on a 70-member ensemble forecast)

OBS



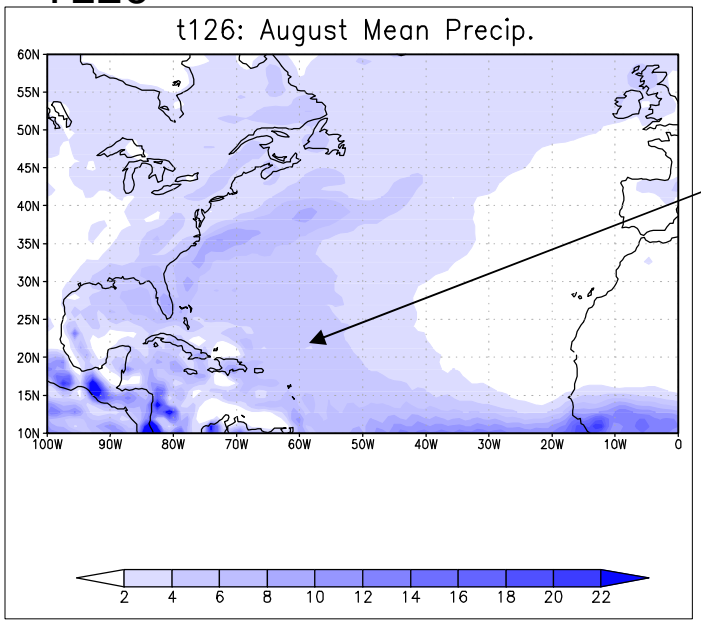
T254



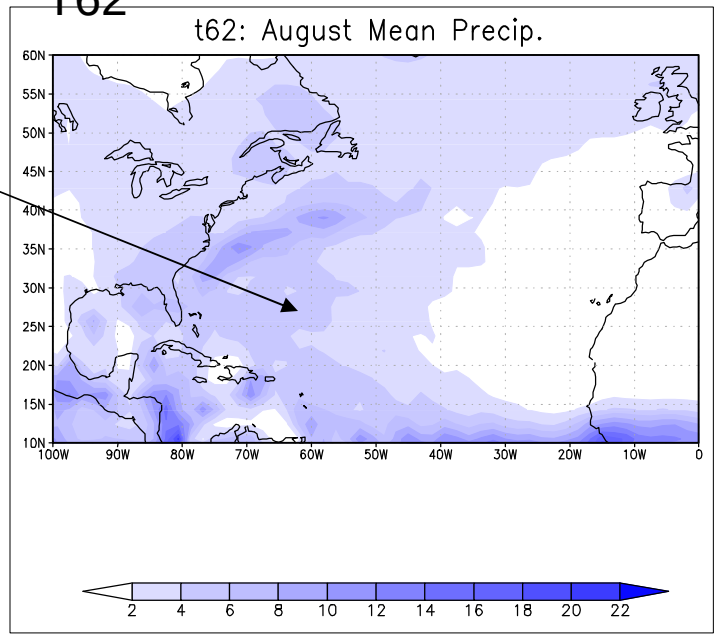
The model is too wet at all resolutions in the western tropical Atlantic.

Is this due to an unrealistically strong dependence on SST (i.e., physics), weak intrusions of dry Saharan air ? – Under investigation

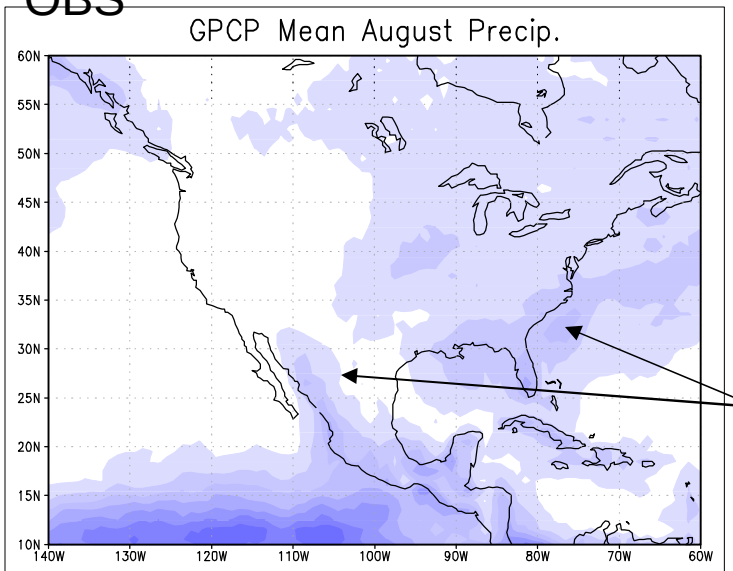
T126



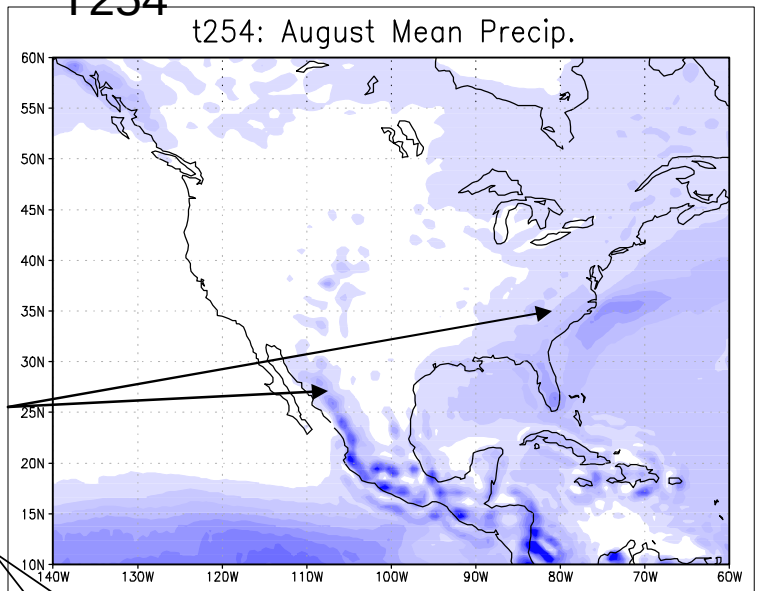
T62



OBS

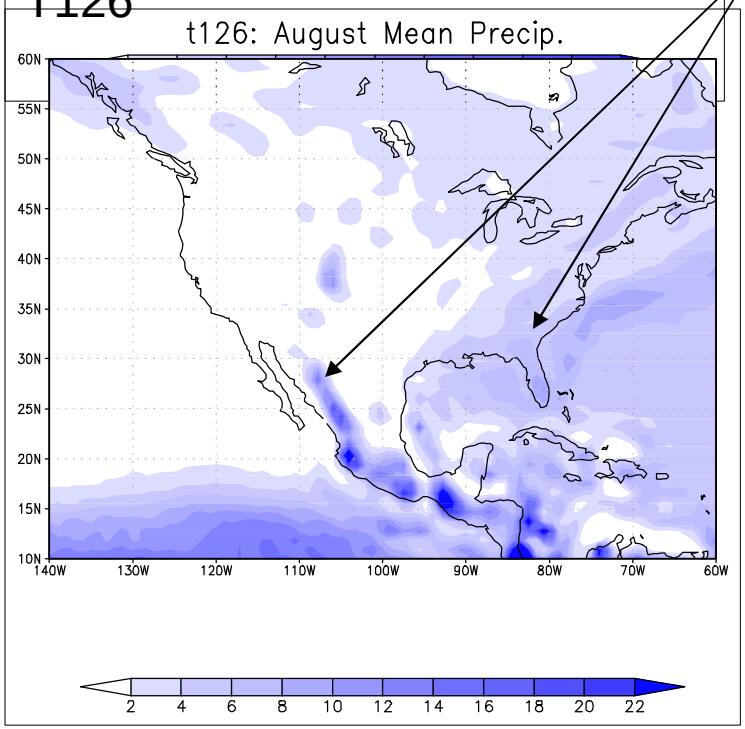


T254

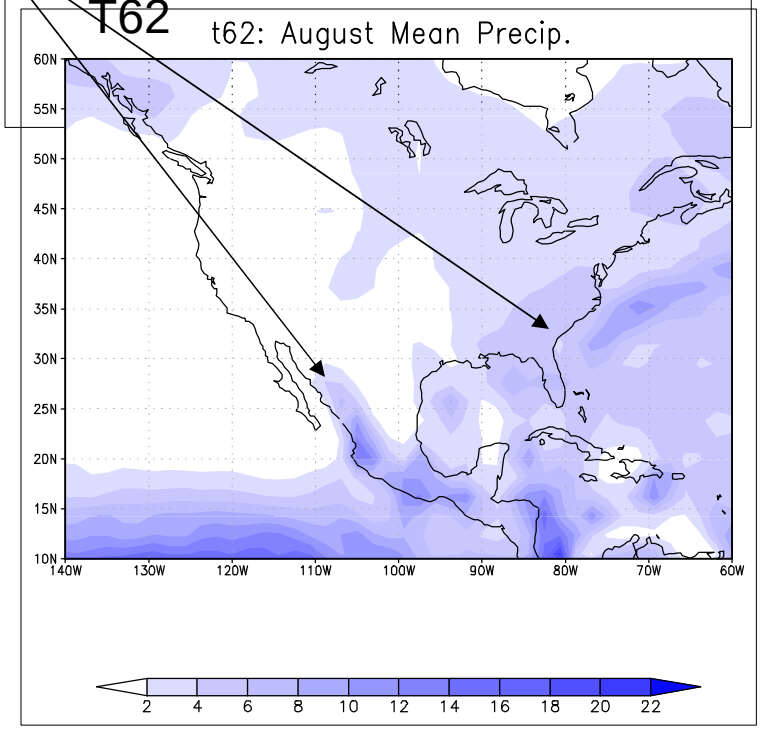


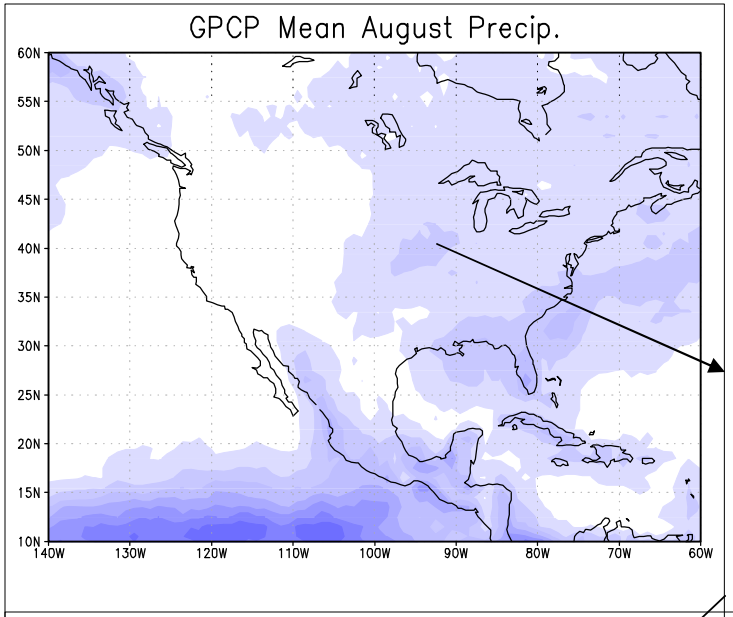
Monsoon and SE areas well simulated

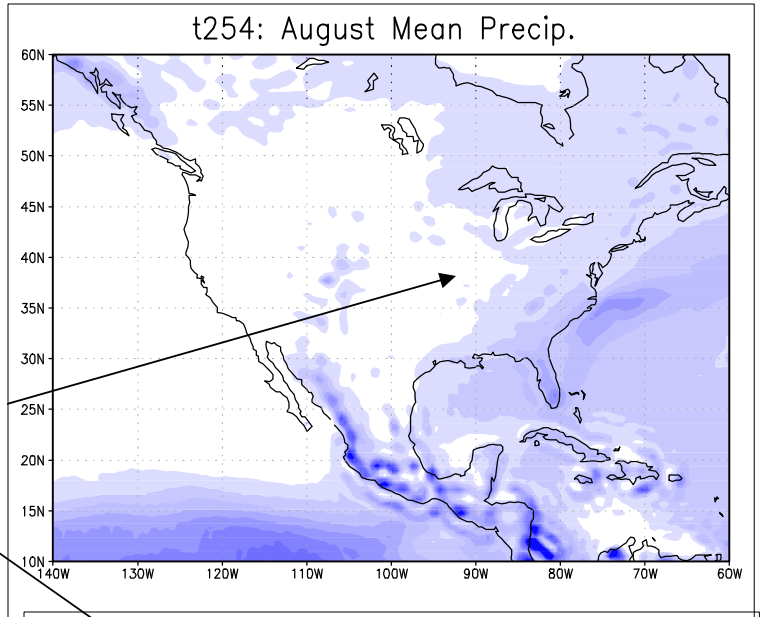
T126



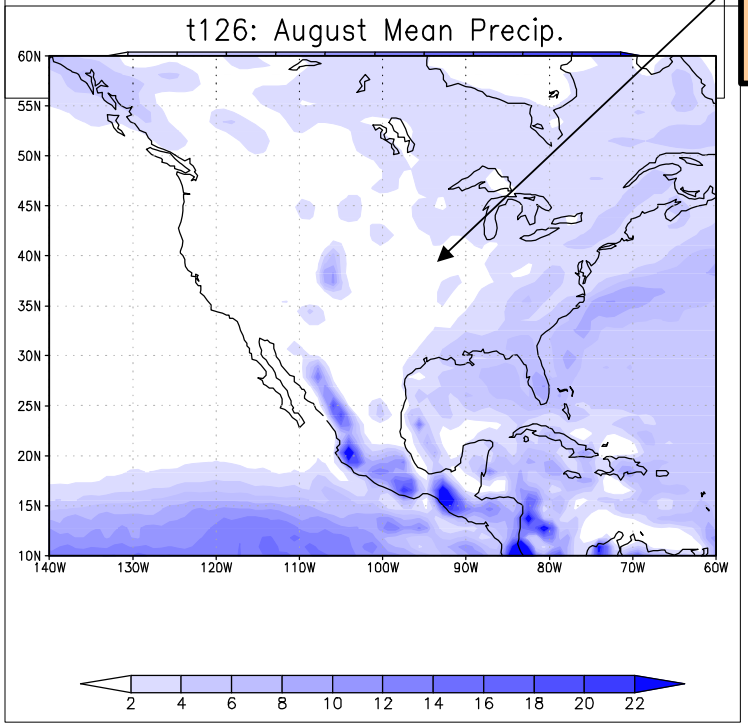
T62

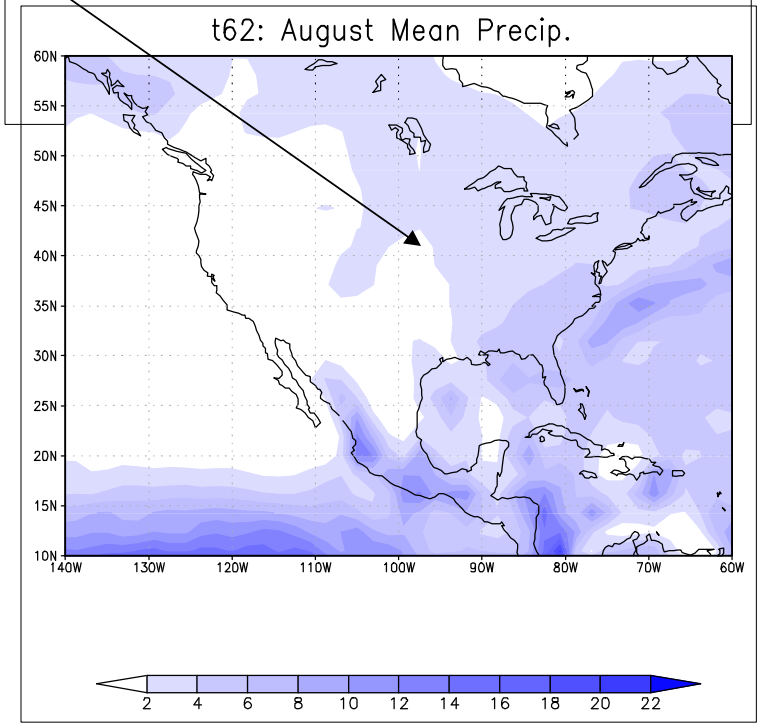






Midwest is too dry at all resolutions – T62 seems to be the best





Forecast of August monthly Precipitation

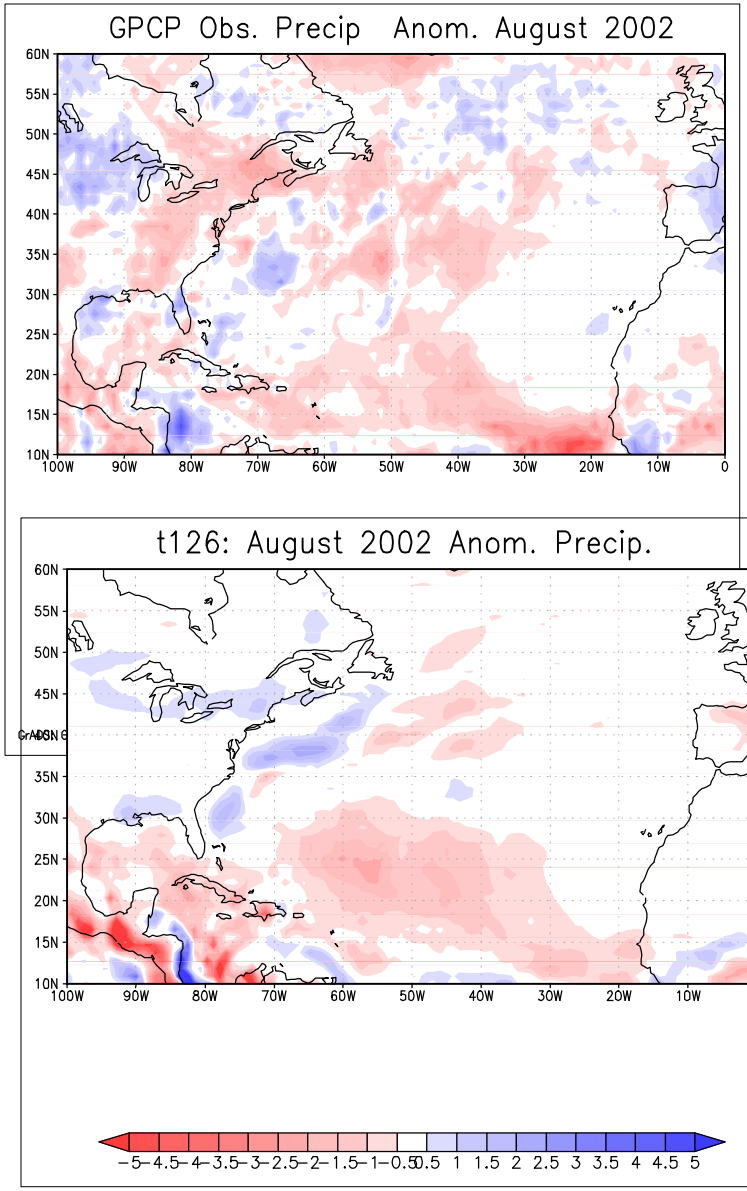
Initial conditions from July 2nd, 3rd, 5th, 6th, 7th, 10th and 12th using both CDAS and GDAS

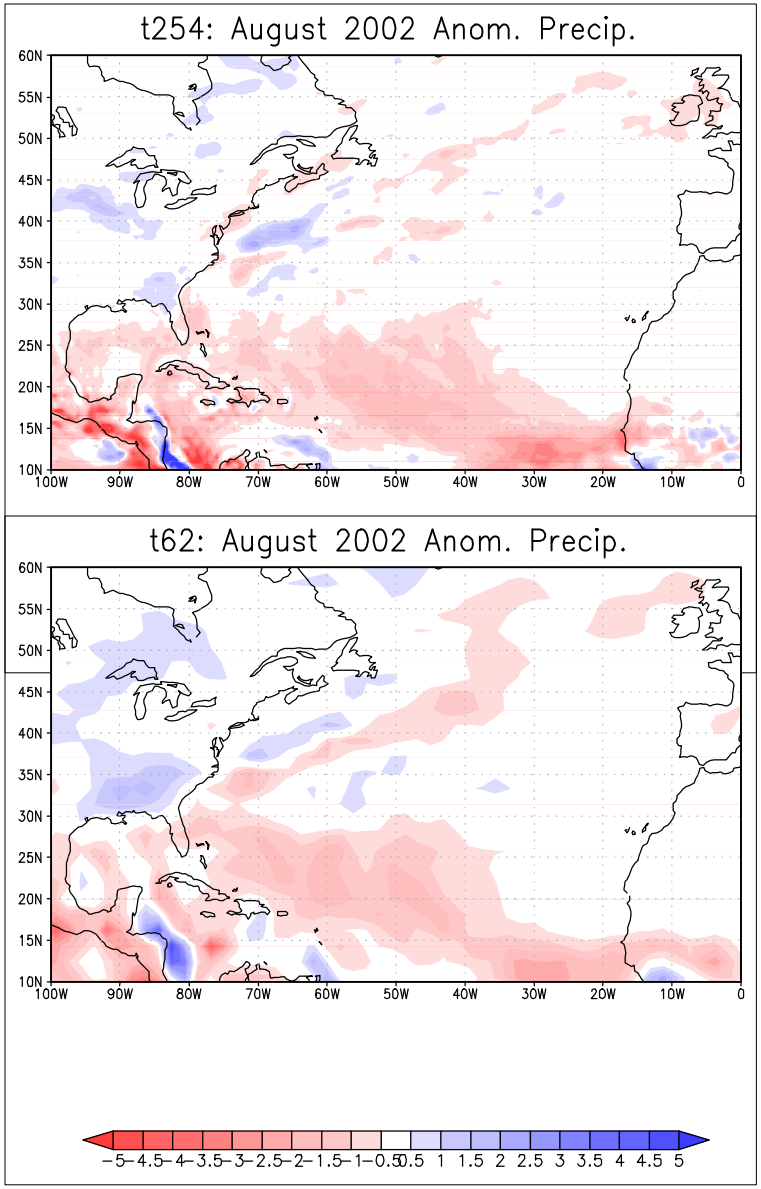
A 14-member ensemble forecast

Tropical Atlantic

August 2002: weak tropical activity

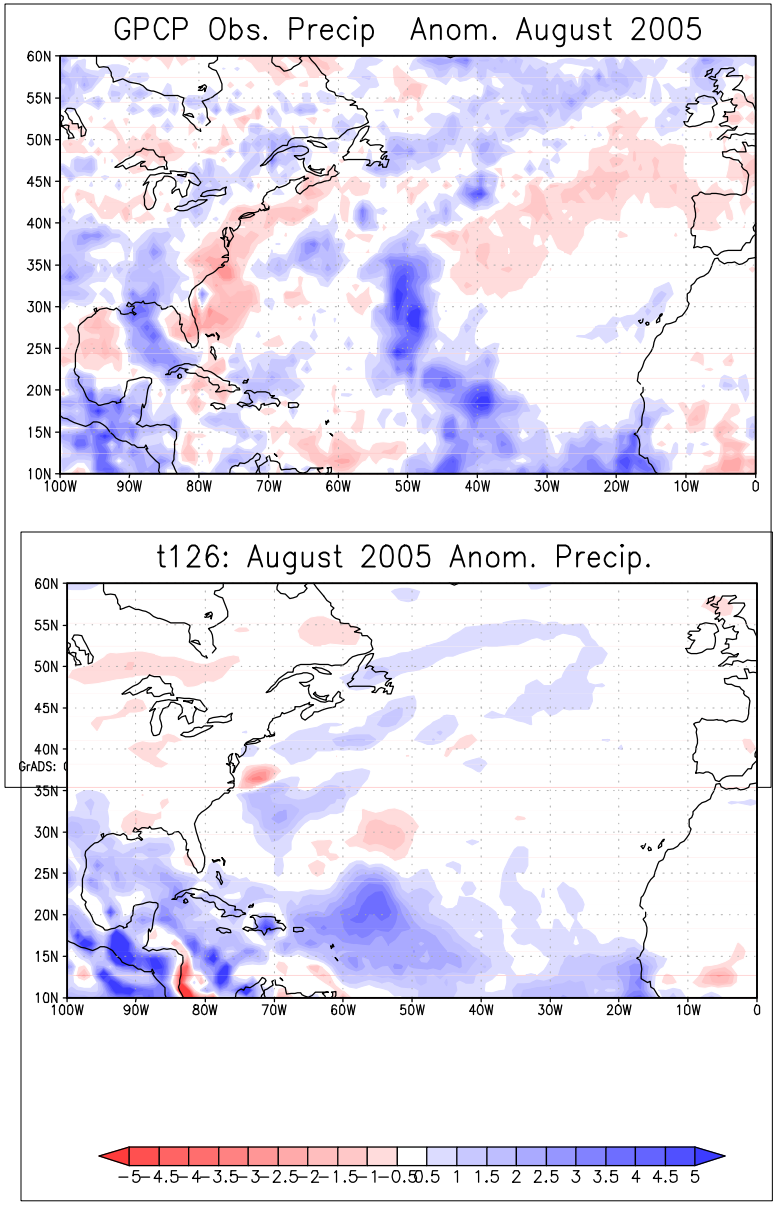
OBS

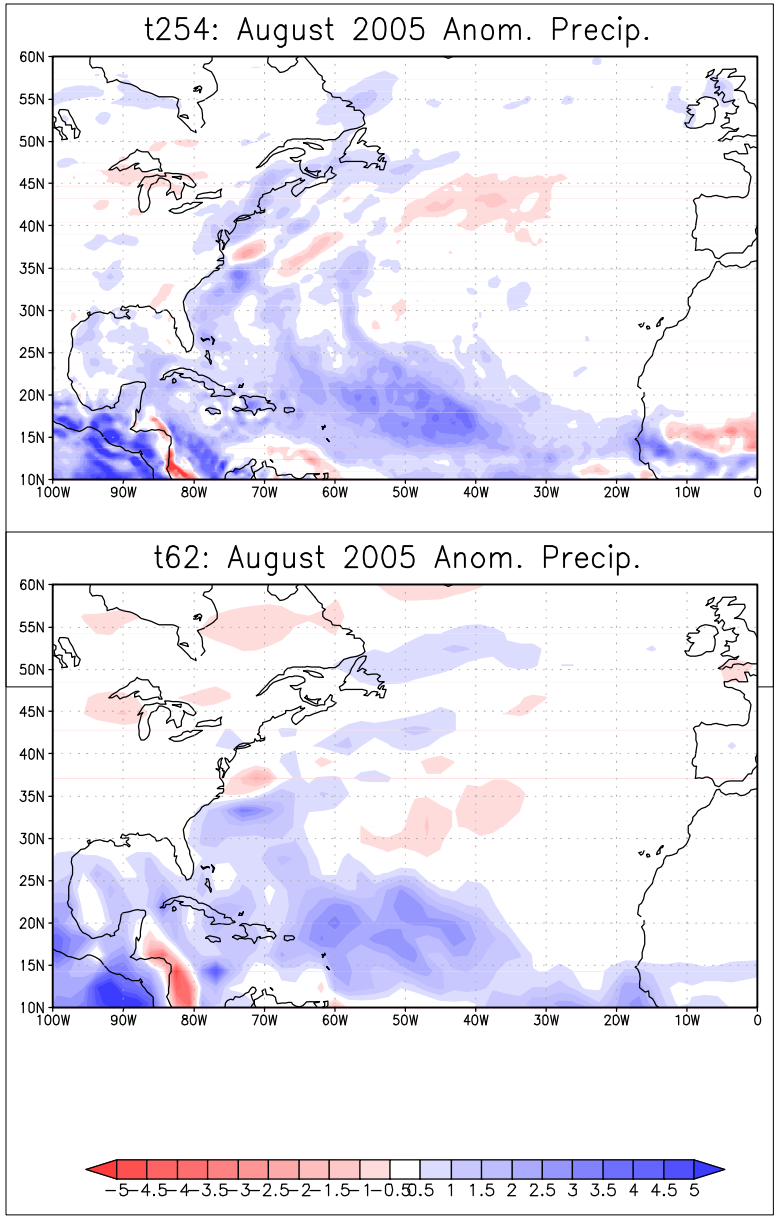




August 2005: **very** strong tropical activity

OBS

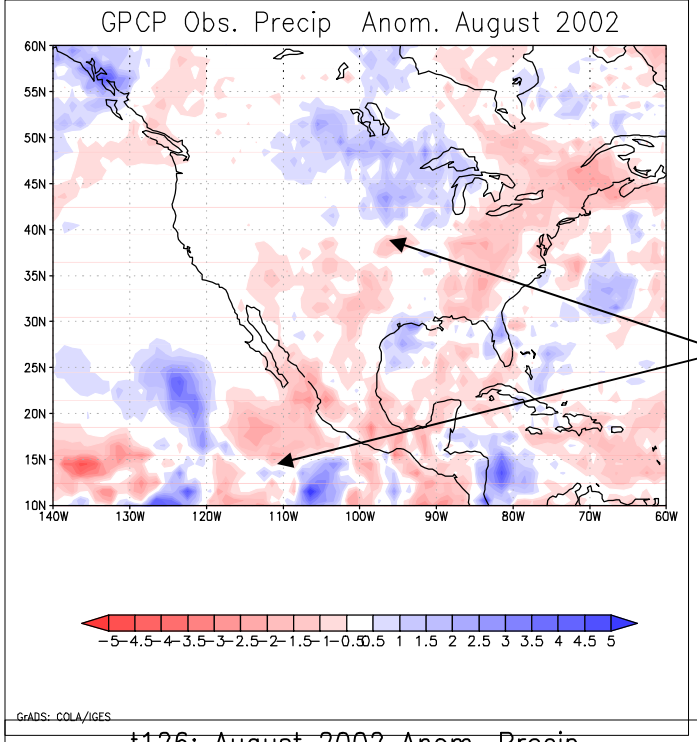


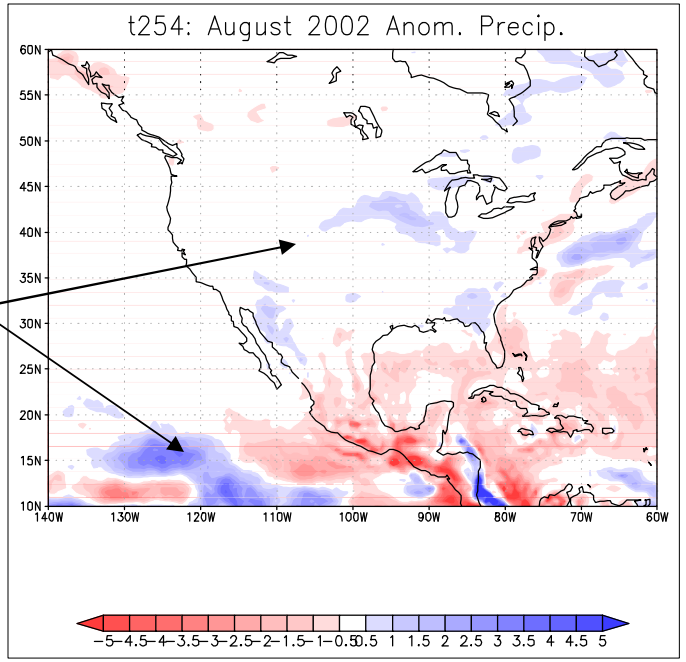


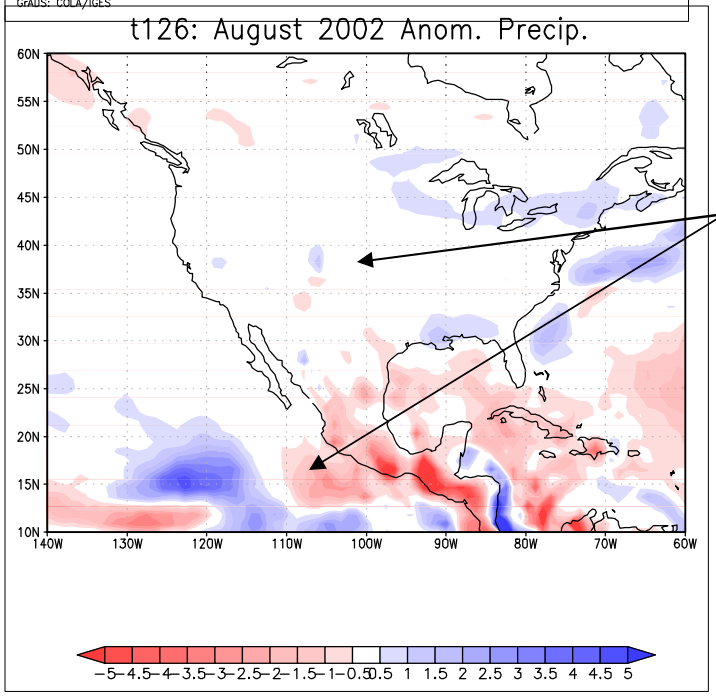
Some conclusions

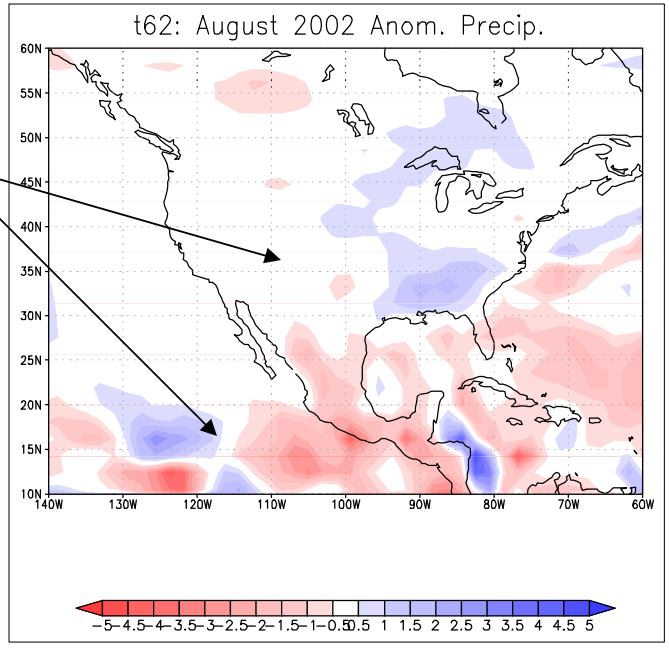
- The model captures very well the contrast between dry conditions in 2002 and wet conditions in 2005 at all resolutions.
- In the real system this contrast was due to lower/higher occurrence of tropical systems.
- We currently investigate if the model response is due to less or more tropical systems or a response to just SST

North American continent



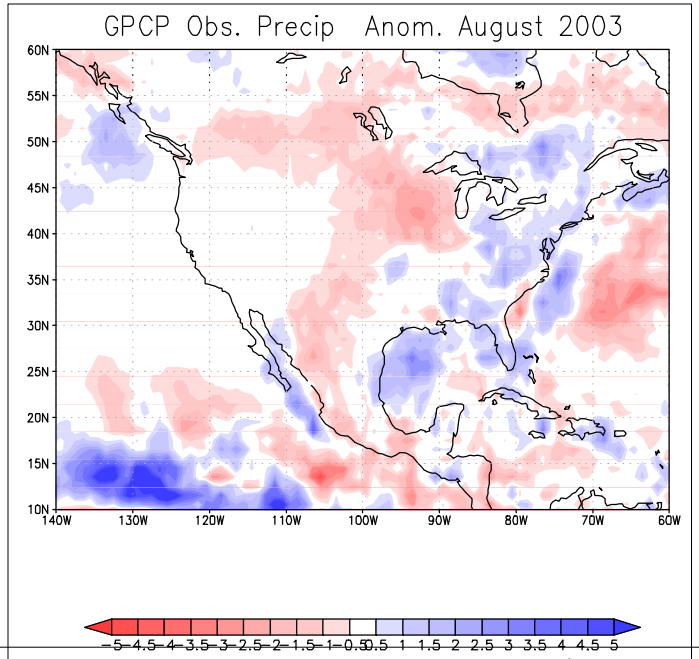


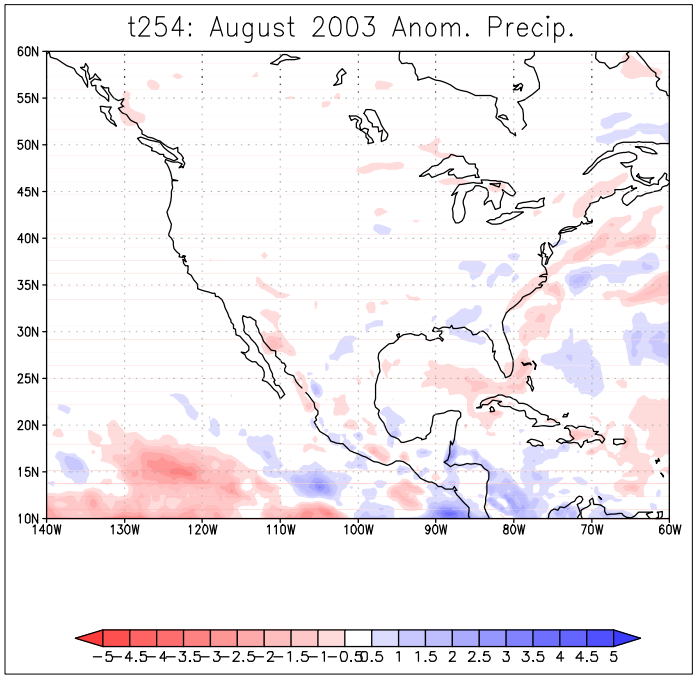


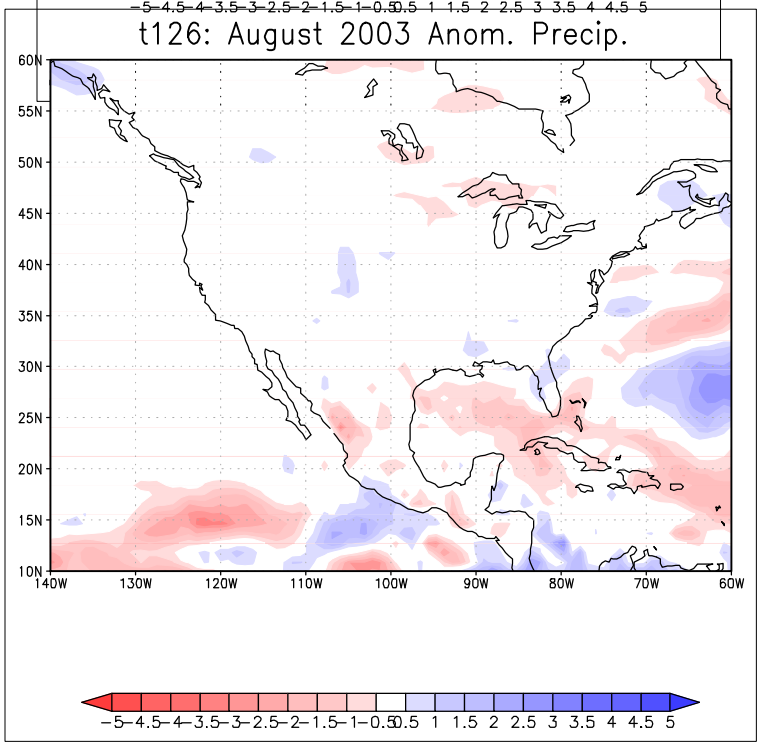


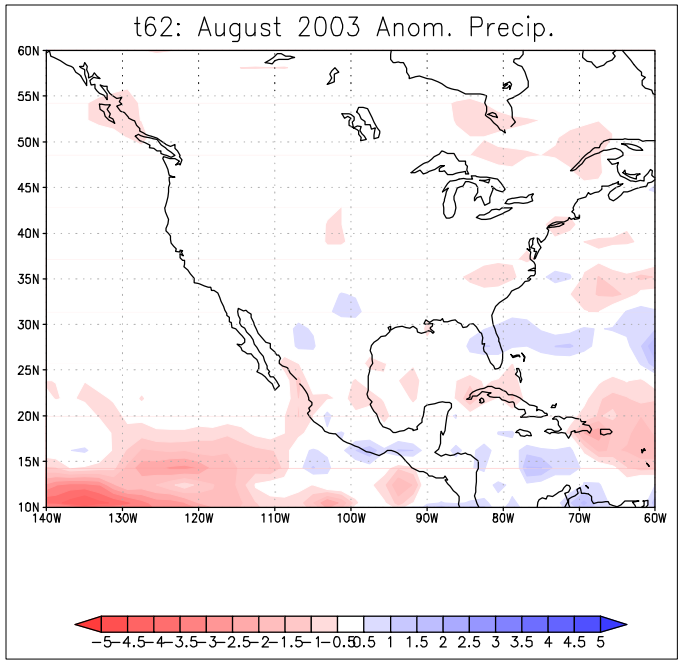
Monthly anomalies over the oceans are simulated with the correct amplitude.

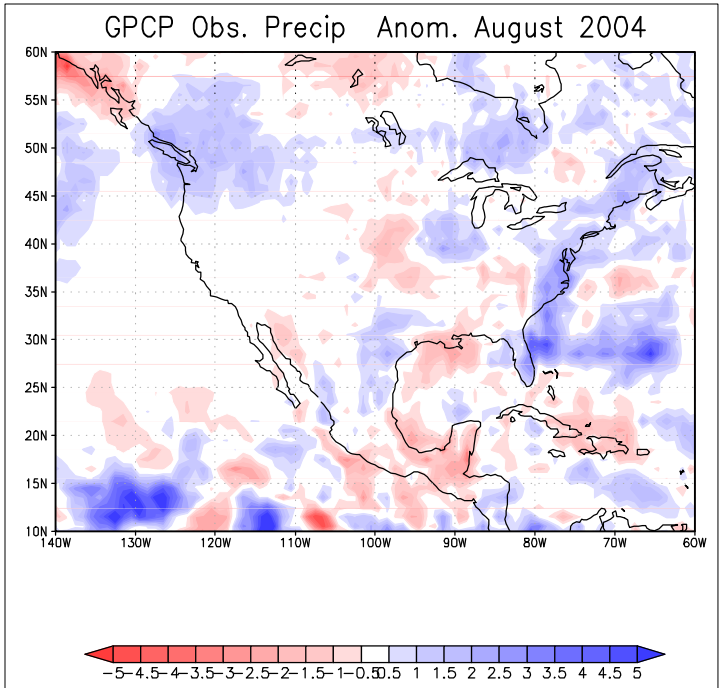
However over the land (with the noticable exception of Mexico) there is only a very weak signal at all resolutions.

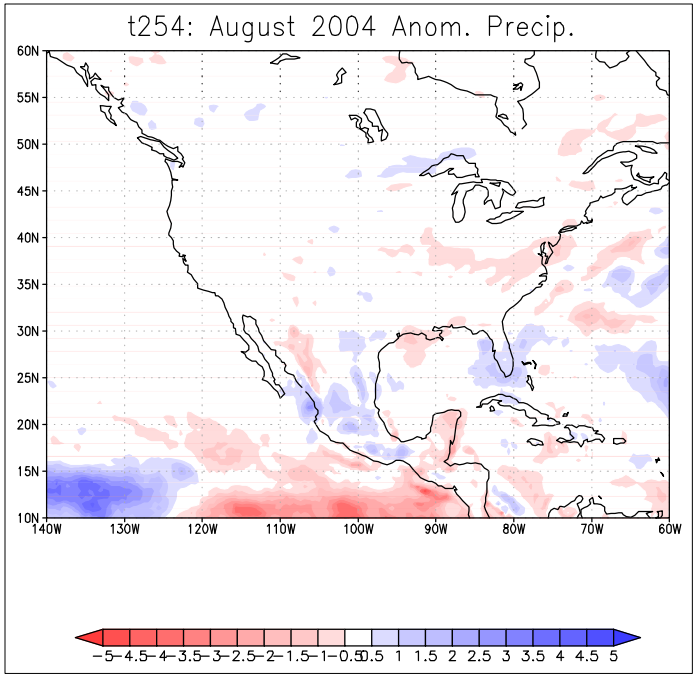

GPCP Obs. Precip Anom. August 2003
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

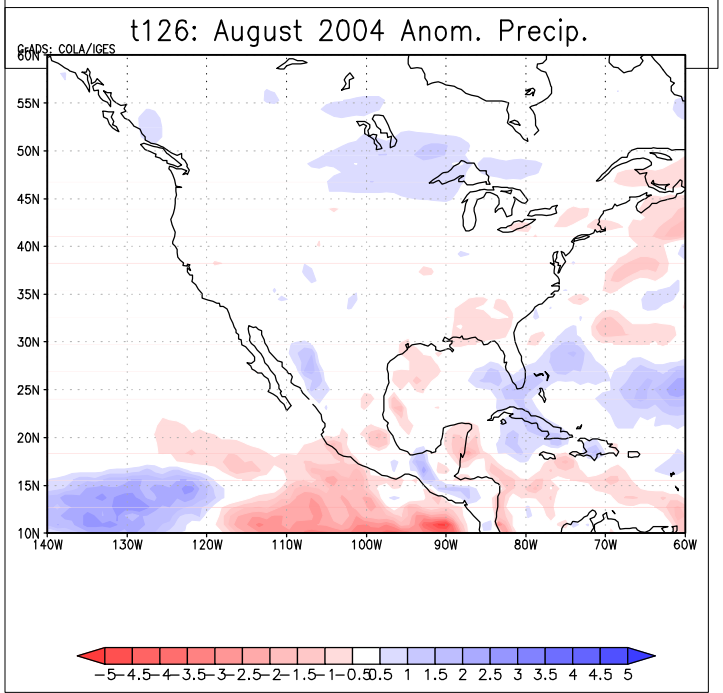

t254: August 2003 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

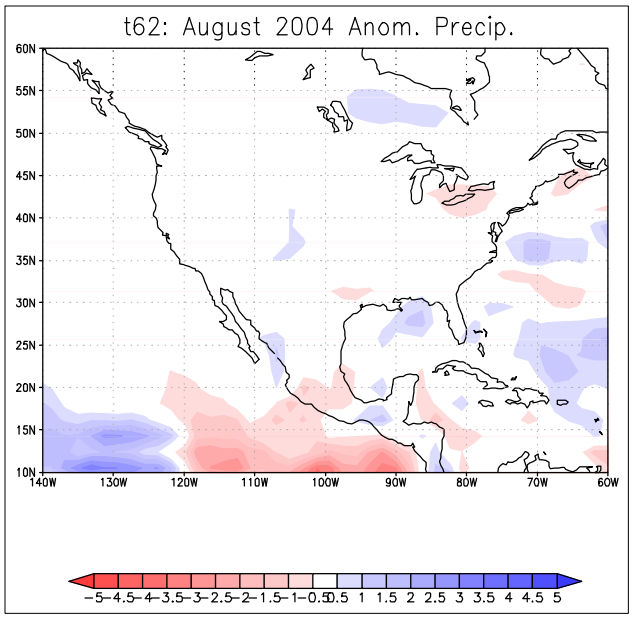

t126: August 2003 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

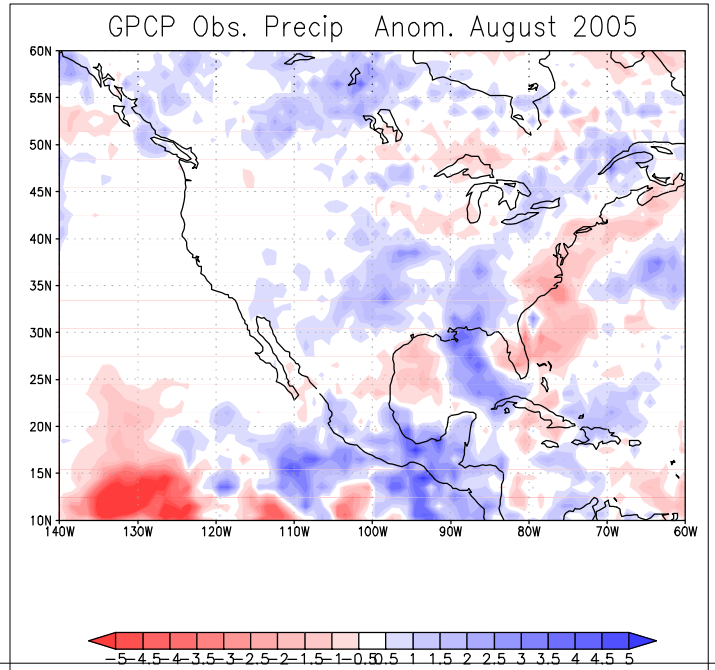

t62: August 2003 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

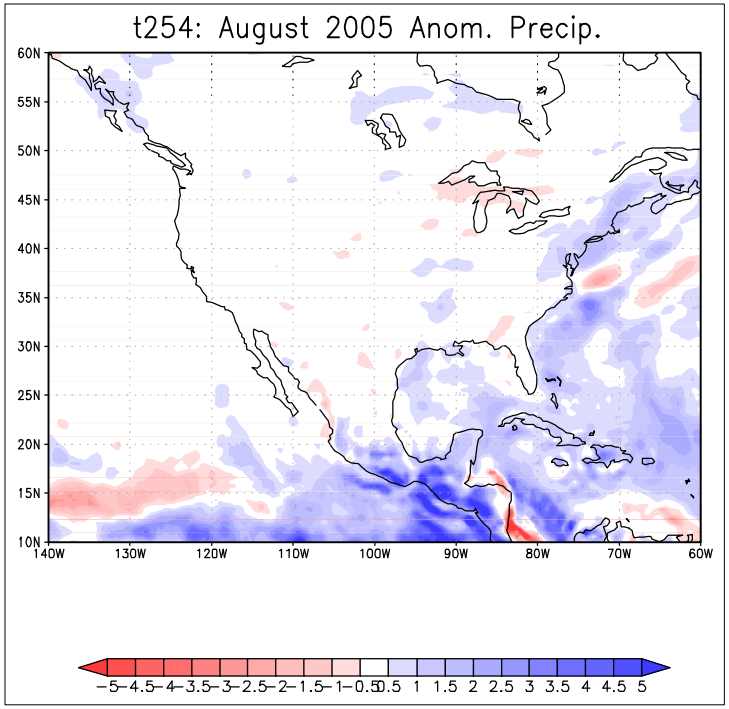

GPCP Obs. Precip Anom. August 2004
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

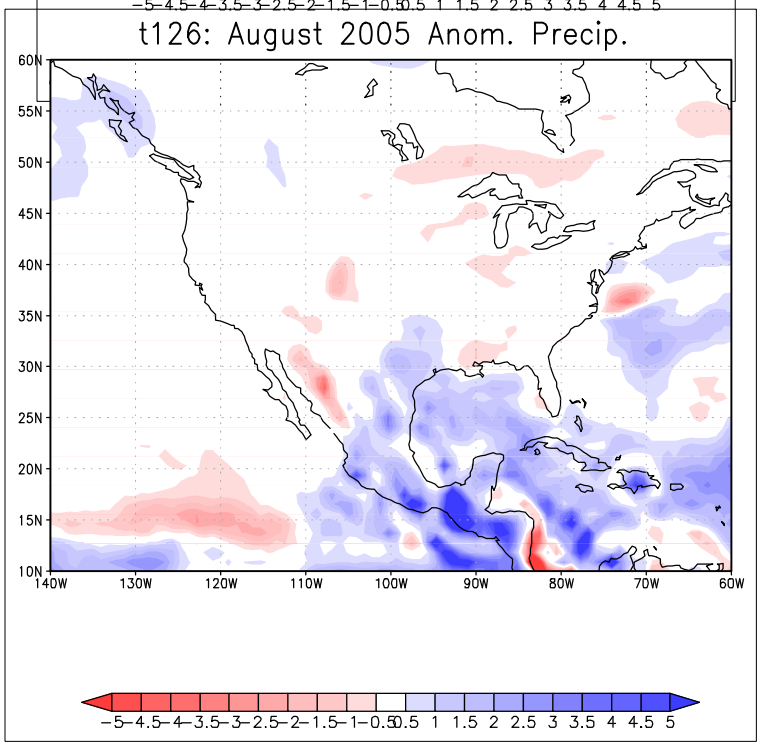

t254: August 2004 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

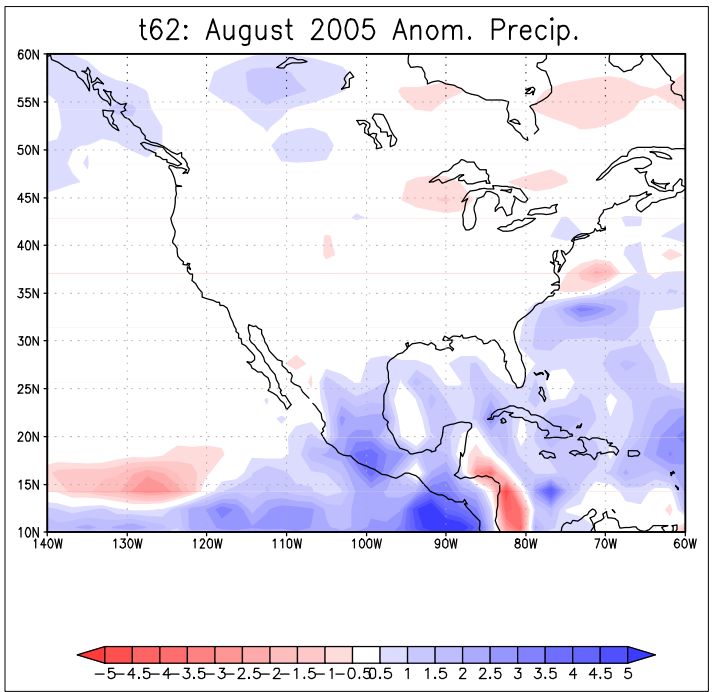

t126: August 2004 Anom. Precip.
GrADS: COLA/IGES
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

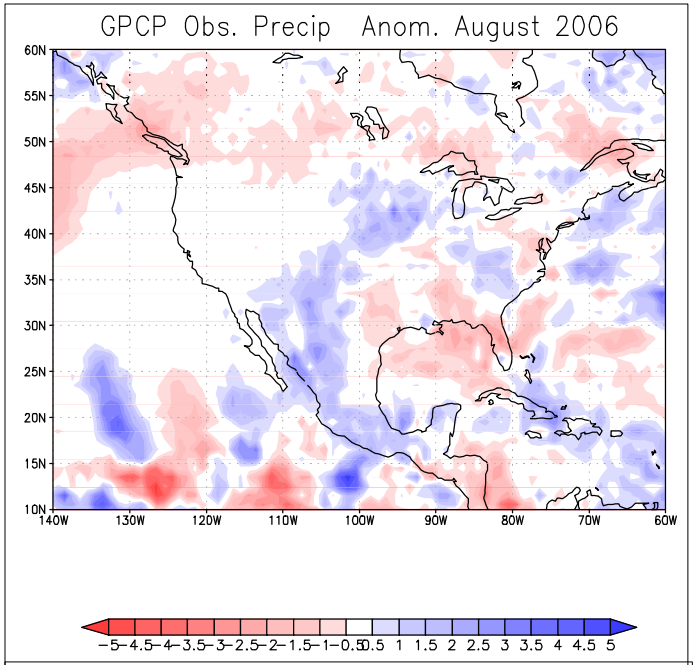

t62: August 2004 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

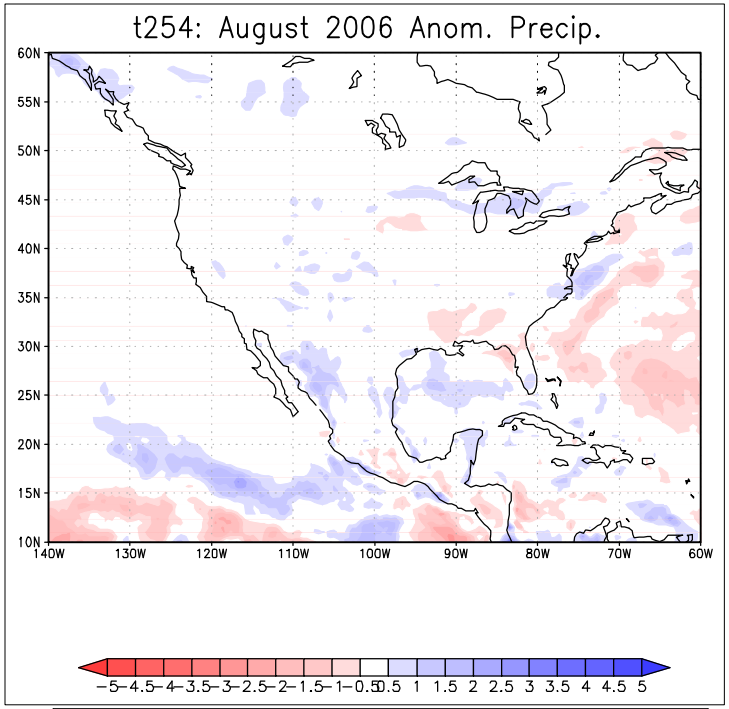

GPCP Obs. Precip Anom. August 2005
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

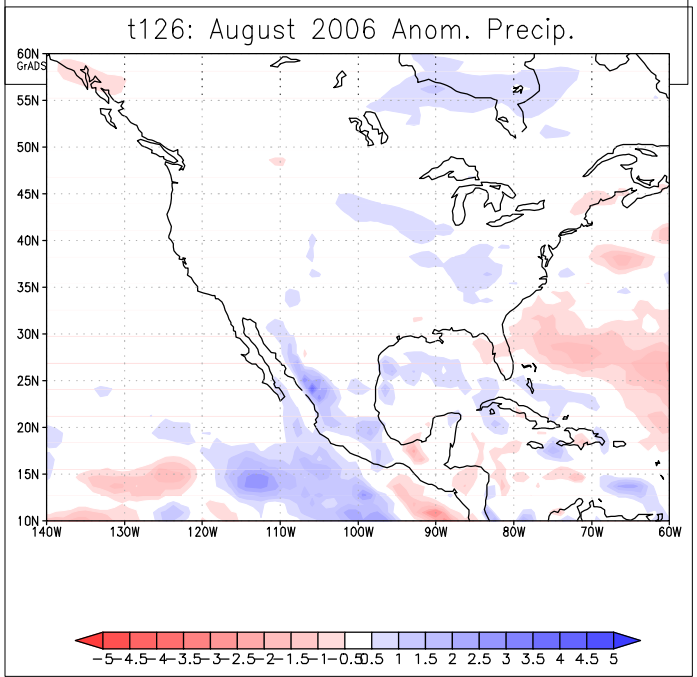

t254: August 2005 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

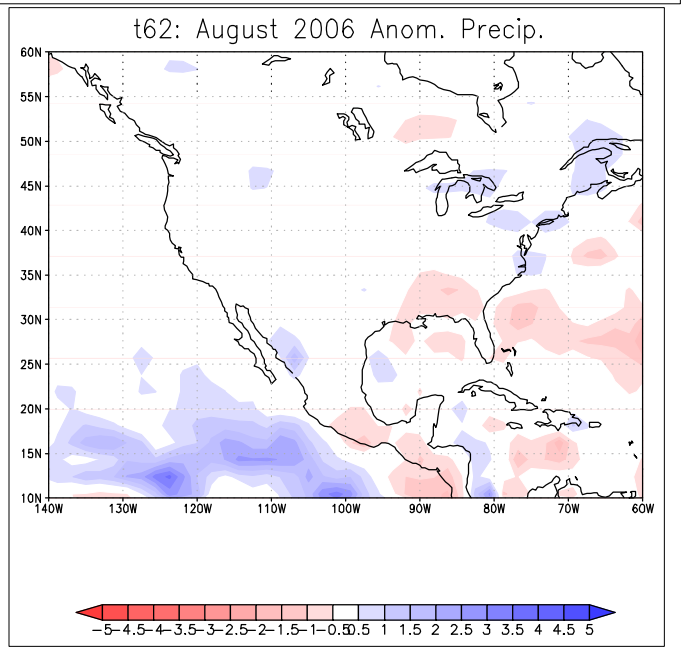

t126: August 2005 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5


t62: August 2005 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5


GPCP Obs. Precip Anom. August 2006
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5


t254: August 2006 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5


t126: August 2006 Anom. Precip.
60N
GrADS
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5


t62: August 2006 Anom. Precip.
60N
55N
50N
45N
40N
35N
30N
25N
20N
15N
10N
140W
130W
120W
110W
100W
90W
80W
70W
60W
−5 −4.5 −4 −3.5 −3 −2.5 −2 −1.5 −1 −0.5 0.5 1 1.5 2 2.5 3 3.5 4 4.5 5

Conclusions

-- We performed a series of hindcasts initialized during summer months in order to asses the impact of atmospheric model resolution and initial conditions to subseasonal forecasts.

-- We presented some indication that even for very large scale fields the impact of initial conditions can be felt as long as week 3 and that resolution plays a role with T254 experiments initialized by GDAS being the best and T62 hindcasts initialized by CDAS being the worst.

-- In this preliminary assessment we have noted that there are areas (e.g., United States) where increasing resolution improves neither the mean state nor variability of precipitation. For these areas improvements of the parameterization of physical processes (or GLDAS) may be the key.

-- There are also areas like the Sahel where resolution appears to be critical for forecasting the mean climate and departures from it.

-- Of course there are technical constraints that do not allow (at present) the operational implementation of resolutions higher than T126 for subseasonal-to-seasonal forecasts. Dynamical downscaling may therefore be an intermediate solution.